J Sci Food Agric 1989, **49**, 281–290

Effect of Chlorothalonil Application Frequency on Quality Factors of Peanuts (*Arachis hypogaea*)

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(Received 21 June 1988; revised version received 11 January 1989; accepted 26 January 1989)

ABSTRACT

Yield, disease rating, seed quality and seed size parameters were determined from four peanut (Arachis hypogaea *L) genotypes with different levels of resistance to leafspot to evaluate the effects of controlling peanut leafspot with chlorothalonil. In 1981 and 1983, main plot treatments were (i) no fungicide applications, (ii) applications of chlorothalonil (1242 g ai ha^{-1}) at 14-day intervals, and (iii) applications of chlorothalonil (1242 g ai ha^{-1}) at 20-day intervals. After shelling, a narrow seed size range (<8·33 mm ⩽ 7·14 mm width) was used to reduce maturity effects in analyses of free fatty acids, total carbonyls, carbohydrates, oil content, and fatty acid profile. Oil content increased significantly with spray frequency in both years only in Southern Runner, and treatment differences in all genotypes were no more than 1·7%. Oleic and linoleic acid decreased and increased, respectively, with increased spray frequency in Florunner (susceptible) and the resistant genotype with the highest unsprayed disease rating. Florunner median seed size for the unsprayed treatment (8·07 mm) was significantly smaller than the median sizes for the 20-day interval (8·15 mm) and 14-day interval (8·16 mm) treatments.*

Key words: Arachis hypogaea, Cercospora arachidicola, Cercosporidium personatum, groundnut.

INTRODUCTION

Peanut (*Arachis hypogaea* L) leafspot diseases, caused by *Cercospora arachidicola* Hori and *Cercosporidium personatum* (Berk and Curt) Deighton, are significant yield-reducing diseases common in the southeastern United States. Leafspot diseases are controlled with fungicidal sprays applied at regular intervals beginning as early as 30–40 days after planting (Shokes *et al* 1983; Ofiara and Allison 1984). When control is not maintained, yield losses occur, including pods that are lost from the plants before or at harvest. Porter (1970) reported harvested yields/pods lost in the soil of 2289/869 and 355/1168 kg ha^{-1} for untreated peanuts and 4176/340 and 3799/495 kg ha^{-1} for benomyl-treated peanuts in 1968 and 1969, respectively. More peanuts were lost at harvest from untreated plants, and the decrease in total production (harvest plus lost) thus resulted from pods lost earlier and/or from decreased production potential of the infected plants. Worthington and Smith (1973) stated that fungicidal applications alter the physiological condition of the plant during the latter period of fruit set and development. To determine the effects of various fungicides, Worthington and Smith (1973, 1974) and Beuchat *et al* (1974) examined fatty acid composition, oil stability, oil content and protein content of samples containing all seed wider than a 'standard' Federal–State Inspection Service slotted screen. Although not specified in those reports, the screen probably had a 6·35 mm width. Worthington and Smith (1973) found that differences in fatty acid composition due to selected fungicide treatments (14-day schedule) versus control were no larger than usual year-to-year differences. They reported increases in oleic acid and decreases in linoleic acid with delayed harvest for all fungicide treatments combined. Sources of difference were suggested to be associated with an extended period of plant vigour and a change in the proportions of mature and immature seed in treatments versus control samples. Beuchat *et al* (1974) reported that chlorothalonil-treated (14-day schedule) and control Florunner samples were not significantly different in relative maturity as measured by Arginine Maturity Index. Young *et al* (1972) reported that leafspot control with chemicals, such as Benlate and Bravo, may delay maturity in runner-type peanuts so that they may be harvested later. Sanders and Blankenship (1984) reported that reduction of soil temperature resulted in delayed maturation of peanuts. More extensive shading of soil and thus lower soil temperatures should occur under conditions of extended plant vigour and retention of leaves, as opposed to leaf loss from leafspot. As harvest is delayed towards optimum, more and more mature peanuts are found on plants. Peanut maturity and seed size are related in that peanuts generally increase in size as they mature; however, many factors affect the year-to-year relationship (Davidson *et al* 1978). The fact that maturity may play a role in compositional differences prompted the present examination of a more defined size range of peanuts than had been examined previously (Worthington and Smith 1973, 1974; Beuchat *et al* 1974). Literature is available on the differences in peanut composition due to maturity (Pattee *et al* 1974; Basha *et al* 1976; Sanders 1979; Oupadissakoon *et al* 1980; Sanders *et al* 1982). Because a size–maturity relationship does exist, examination of a narrow size range of peanuts should reduce the effect of maturity on composition data.

Reduced yield due to leafspot has received extensive research consideration due to the associated financial loss to producers. The per cent of seed in each commercial size category within harvested lots also has financial impact due to the different prices for various commercial sizes. In a review of literature the present authors did not find information on the effect of leafspot on seed size distribution in peanuts when yields were significantly reduced. The objectives of this work were to determine the effect of chlorothalonil application frequency on (1) composition of peanuts of a defined size range, and (2) seed size distributions of susceptible and resistant peanut genotypes.

MATERIALS AND METHODS

In 1981 and 1983 peanut genotypes UF81206, Southern Runner, 72x93-9-1-1B and Florunner were grown at the Agricultural Research and Education Center, in Marianna, Florida. In each year the experiment was replicated four times in a split-plot arrangement of a randomized complete block design in which the two fungicide spray schedules and an unsprayed treatment were the main plots. Spray schedules were as follows: (i) no fungicide application; (ii) chlorothalonil, as a 500 g litre^{-1}, flowable formulation applied at 2·48 litre ha^{-1} (1242 g ai ha^{-1}) on a 14-day spray interval beginning 40 days after planting, and (iii) chlorothalonil applied on a 20-day schedule beginning 60 days after planting. Chlorothalonil was applied with a tractor-mounted sprayer in 168 litres of water ha^{-1} at 345 kPa. Subplots were peanut entries planted 1 June 1981 and 24 May 1983 in two-row plots (91 cm apart, 6·1 m long). Plots were planted with a cone planter to uniformly distribute 60 seeds per row. Unsprayed border rows of Florunner separated main plots and served as spreader rows to enhance disease pressure. Cultural practices, except for chlorothalonil spray frequency, were the same for all plots. Leafspot severity was scored 2 days before harvest in both years by using a rating scale of 1 to 10 based on lesion number, lesion area, and defoliation (Gorbet *et al* 1986). The rating was based on 1 = no disease and 10 = dead plants.

Peanuts were harvested with a digger–shaker–inverter at 136 and 138 days after planting in 1981 and 1983, respectively. All plots were picked with a stationary peanut thresher 3 days after digging. Peanut pods were cured to 10% w/w moisture with heated air (35°C) and weighed by plot.

From the plot yields approximately 700 g of peanut pods were sampled for further analysis. Pods from 1981 were held in 4°C storage for approximately 12 months and pods from 1983 were held for approximately 3 months at which times they were shelled. Split kernels were removed and whole kernels were screened over slotted hole screens as described by Davidson *et al* (1978). Eight screens were used that ranged from 4·76 mm (12/64 in) to 10·32 mm (26/64 in) in approximately 0·3 mm (2/64 in) increments. The cumulative per cent of kernels, by weight, that rode each screen was calculated and plotted to provide the seed size distribution. Seed size distribution data were fitted to the cumulative function for the logistic distribution (CDF) as described by Davidson *et al* (1978) and Williams *et al* (1988).

The CDF may be written in the form

$$y = 100[1 - 1/(1 + e^{-\gamma(x-\mu)})]$$

where y is the percentage of seeds that ride a given screen size, x. The equation parameter, μ, is the mean seed size (mm) and γ is a parameter related to the slope. The parameters were estimated using the SAS procedure NLIN (SAS Institute 1985). Peanuts that fell through an 8·33 mm (21/64 in) slotted screen and rode a 7·14 mm (18/64 in) slotted screen were used for analysis of total oil content (AOCS 1969), free fatty acids (AOCS 1969), fatty acid profile (Sanders 1979), total carbonyls (Henick *et al* 1954) and carbohydrates (Oupadissakoon *et al* 1980).

In 1983, 450-g samples of peanut pods from each plot were hand-shelled and maturity was determined by using the shellout method based on the percentage of pods with tan-brown internal pericarp colour (Henning and McGill 1974).

RESULTS

Florunner was the most susceptible to leafspot disease in 1981 and 1983 tests (Table 1). All genotypes had lower disease severity ($P = 0·05$) with increased frequency of fungicide application. The greatest reduction in disease severity occurred on Florunner, but it still had more leafspot than the resistant genotypes under the 14- and 20-day spray schedules.

Fungicide application was effective in increasing yields for all genotypes (Table 2). UF81206 had the highest unsprayed yield in 1983 and one of the two highest in 1981. It had the lowest unsprayed disease rating in both years. Florunner had the greatest yield and reduction in disease rating in response to the fungicide treatments. However, except for Florunner in both years and Southern Runner in 1981, increasing the frequency of spray did not produce increases ($P = 0·05$) in yield.

In 1983, no differences in proportion of mature pods were found among the

TABLE 1

Leafspot disease ratings* of peanut genotypes sprayed with chlorothalonil (14- or 20-day interval) and unsprayed in 1981 and 1983 at Marianna, FL

Genotype	*1981*			*1983*		
	Unsprayed	*20-day*	*14-day*	*Unsprayed*	*20-day*	*14-day*
Florunner	8·5[a]	3·8[b]	2·6[c]	7·5[a]	5·6[b]	3·4[c]
Southern Runner	4·8[a]	2·8[b]	2·3[c]	4·1[a]	3·5[b]	2·0[c]
UF81206	4·0[a]	2·6[b]	2·3[b]	3·4[a]	2·8[b]	1·5[c]
72x93-9-1-1-B	4·9[a]	2·5[b]	1·8[c]	4·1[a]	3·3[b]	2·1[c]
LSD 0·05	1·0	0·4	0·5	0·5	0·2	0·4

* Subjective visual rating based on lesion number, lesion area and defoliation.
Within-years treatment means for a genotype followed by the same letter are not significantly different (Duncan's New Multiple Range Test, $P = 0·05$ level).
LSD values are for comparisons among genotypes for each treatment and year.

TABLE 2
Mean pod yields of peanut genotypes sprayed with chlorothalonil (14- or 20-day interval) and unsprayed in 1981 and 1983 at Marianna, FL

Genotype	*Pod yield (kg ha^{-1})*					
	1981			*1983*		
	Unsprayed	*20-day*	*14-day*	*Unsprayed*	*20-day*	*14-day*
Florunner	2780^{a}	5423^{b}	6048^{c}	2826^{a}	4538^{b}	5407^{c}
Southern Runner	4330^{a}	4884^{b}	5448^{c}	4478^{a}	5341^{b}	5560^{b}
UF81206	4838^{a}	5646^{b}	5992^{b}	5087^{a}	5550^{a,b}	5620^{b}
72x93-9-1-1	4899^{a}	5540^{b}	5784^{b}	4157^{a}	4614^{b}	4752^{b}
LSD 0·05	1244	403	NS	464	354	187

Within-years treatment means for a genotype followed by the same letter are not significantly different (Duncan's New Multiple Range Test, $P = 0{\cdot}05$).
LSD values are for comparisons among genotypes for each treatment and year.

TABLE 3
Total oil content (g per 100 g) of peanuts sprayed at 14- or 20-day intervals with chlorothalonil and unsprayed in 1981 and 1983 at Marianna, FL

Genotype	*Oil content (g per 100 g)*					
	1981			*1983*		
	Unsprayed	*20-day*	*14-day*	*Unsprayed*	*20-day*	*14-day*
Florunner	45·9^{a}	46·7^{a,b}	47·6^{b}	50·5^{a}	50·8^{a}	51·1^{a}
Southern Runner	50·2^{a}	51·0^{b}	51·2^{b}	51·5^{a}	52·1^{a,b}	52·9^{b}
UF81206	51·5^{a}	51·1^{a}	52·2^{a}	53·1^{a}	53·5^{a,b}	54·1^{b}
72x93-9-1-1-B	46·6^{a}	46·6^{a}	46·4^{a}	49·9^{a}	50·3^{a}	49·9^{a}

Within-years treatment means followed by the same letter are not significantly different (Duncan's New Multiple Range Test, $P = 0{\cdot}05$).

treatments which ranged from 55·1 to 65·5%. Total oil content increased significantly ($P = 0{\cdot}05$) with spray treatment in at least one year for three of the four genotypes (Table 3). The trend for higher oil content with increased frequency of spray was significant in both years only for Southern Runner. The largest percentage difference among treatments for a genotype was 1·7%.

Neither carbonyl content, free fatty acid content, nor carbohydrate concentration was significantly affected by spray treatment. The free fatty acid content for all genotypes and treatments in 1981 and 1983 was less than 0·16 g per 100 g.

Oleic and linoleic acid content of oil from the four genotypes in 1981 and 1983 are presented in Table 4. Other fatty acids in the oils were within normal values and no differences were found due to treatment. Numerical trends of decreasing oleic and increasing linoleic acid with increased frequency of spray were observed. However, means were not consistently significantly different for a given genotype and year.

TABLE 4

Oleic and linoleic acid content in oil of peanut genotypes sprayed with chlorothalonil (14- or 20-day intervals) and unsprayed in 1981 and 1983 at Marianna, FL

Genotype	*Treatment*	*1981*		*1983*	
		Oleic acid	*Linoleic acid*	*Oleic acid*	*Linoleic acid*
		mole %			
Florunner	Unsprayed	51·2^{b}	31·8^{a}	53·0^{b}	27·8^{a}
	20-day	47·5^{a}	37·4^{b}	53·1^{b}	28·4^{a}
	14-day	46·3^{a}	38·2^{b}	51·5^{a}	29·8^{b}
Southern Runner	Unsprayed	53·6^{a}	25·6^{a}	53·9^{a}	25·8^{a}
	20-day	52·2^{a}	26·7^{a}	53·7^{a}	26·2^{a}
	14-day	51·7^{a}	27·3^{a}	52·9^{a}	27·8^{a}
UF81206	Unsprayed	56·9^{a}	22·6^{a}	59·5^{a,b}	21·0^{a}
	20-day	55·0^{a}	24·0^{a}	60·3^{b}	20·8^{a}
	14-day	55·0^{a}	24·0^{a}	58·3^{a}	22·3^{a}
72x93-9-1-1-B	Unsprayed	51·2^{b}	27·7^{a}	53·1^{b}	26·8^{a}
	20-day	49·8^{b}	29·5^{b}	51·8^{a}	28·2^{a}
	14-day	48·4^{a}	30·9^{b}	51·6^{a}	28·4^{a}

Within-years treatment means for a genotype followed by the same letter are not significantly different (Duncan's New Multiple Range Test, $P = 0{\cdot}05$).

An ANOVA of the logistic CDF parameters, for the estimated mean seed size μ, and slope parameter, γ, gave highly significant ($P \leq 0{\cdot}001$) year by genotype and spray treatment by genotype interactions. Values for R^2 were greater than 0·98 for individual fits of CDF to the experimental data. The estimated mean seed size differences were small among spray treatments within a given genotype. Mean seed sizes for all genotypes were greater ($P = 0{\cdot}05$) in 1983 than 1981 (Table 5).

DISCUSSION

Our results support previous findings (Gorbet *et al* 1982) that susceptible and resistant peanut genotypes have different quantitative responses to fungicide application frequency (Tables 1 and 2). Number of pods set, size/weight of pods, or maintenance of mature pods through harvest was more consistently affected by fungicide application in Florunner than in the resistant genotypes. All of these yield factors are potentially affected by the supply of photosynthates and soil temperature which should be related to disease severity through leaf condition and defoliation, respectively. Pod set and pod size/weight have been shown to be related to soil temperature (Dreyer *et al* 1981; Sanders and Blankenship 1984).

Quality analyses were performed on specific size seed to reduce the effects of maturity-related composition differences. Quality analyses in which all seed wider than 0·6 cm are utilized are complicated by the variation in composition found in the range of maturity stages in the sample (Pattee *et al* 1974; Basha *et al* 1976;

TABLE 5

Estimates of mean seed size (μ) and slope parameter (γ) for cumulative logistic distribution function as affected by spray schedule and genotype and by crop year and genotype

	Genotype							
	Florunner		*Southern Runner*		*UF81206*		*72x93-9-1-1-B*	
	$\mu(mm)$	γ	$\mu(mm)$	γ	$\mu(mm)$	γ	$\mu(mm)$	γ
Treatment								
Unsprayed	8.07^{b}	2.36^{a}	8.23^{a}	2.60^{a}	8.70^{a}	1.96^{a}	8.29^{a}	2.19^{a}
20-day	8.15^{a}	2.25^{a}	8.22^{a}	2.25^{a}	8.76^{a}	1.87^{ab}	8.21^{b}	2.04^{b}
14-day	8.16^{a}	2.10^{b}	8.22^{a}	2.17^{b}	8.73^{a}	1.77^{b}	8.23^{ab}	1.96^{b}
$LSD_{\mu}=0.076$	$LSD_{\gamma}=0.117$							
Year								
1981	8.07^{b}	2.21^{a}	8.14^{b}	2.04^{b}	8.58^{b}	1.69^{b}	8.22^{b}	1.94^{b}
1983	8.19^{a}	2.26^{a}	8.32^{a}	3.64^{a}	8.87^{a}	2.03^{a}	8.27^{a}	2.19^{a}
$LSD_{\mu}=0.022$	$LSD_{\gamma}=0.034$							

Means in the same column not followed by the same letter are significantly different ($P=0.05$) by least significant difference test.

Sanders *et al* 1982). Size separation reduces the effect of maturity but does not eliminate it. The numerical trend in maturity was for lower shellout percentages with increasing spray frequency, and the data suggested delayed maturation as indicated by Young *et al* (1972) and Sanders and Blankenship (1984).

Factors other than maturity and genotype, contributing to differences in total oil content in peanuts, have not generally been identified. Although it is possible that maturity differences exist in the same size seed from the three treatments, it is unlikely that the observed significant differences in total oil content between spray treatments within a genotype could be ascribed to maturity alone (Sanders *et al* 1982). An alternative hypothesis is that the diminished availability of photosynthates due to leaf loss or necrosis resulted in selective distribution and/or reduced oil synthesis.

The oleic acid to linoleic acid (O/L) ratio is considered by many investigators to be an indicator of oil stability (and therefore keeping quality) (Holaday and Pearson 1974), although correlation coefficients are variable from year to year. The oleic acid and linoleic acid data in Table 4 appear to be related to leafspot severity. Within a genotype, as disease rating decreased in response to spray frequency, the content of oleic acid decreased whereas that of linoleic acid increased. The effect of canopy shade on soil and peanut plant temperatures has been reported (Hill *et al* 1983; Sanders and Blankenship 1984; Sanders *et al* 1985). As soil temperatures decrease, unsaturation increases in peanut oil (Holaday and Pearson 1974) in response to differential solubility of oxygen required for desaturase activity. Soil temperatures under plants with high levels of disease and subsequent defoliation should be slightly higher due to direct incidence of sunlight on the soil than soil temperatures under plants with low disease rating and healthy foliage. Therefore, the degree of saturation in oil should follow disease severity.

Mean seed size (μ) differences were small within a genotype, and only Florunner exhibited a consistent increase in estimated mean seed size in response to chlorothalonil spray. In terms of the distribution of seed sizes, this indicates that a

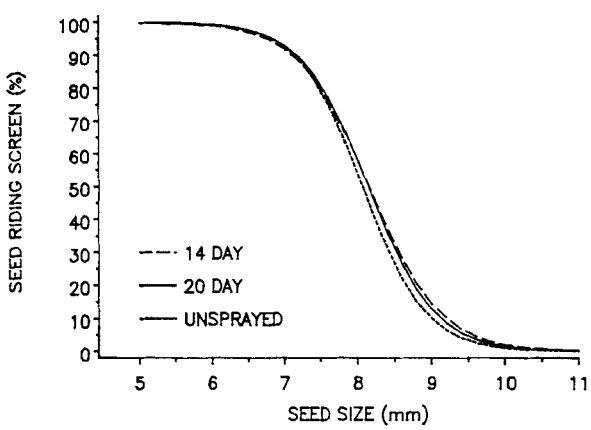

Fig 1. Plot of the logistic cumulative distribution function fit to the Florunner seed size distributional data for the combined years of 1981 and 1983.

greater proportion of the larger seed sizes were contained in the sample lot. Differences in seed size distribution and thus mean seed size have been reported by Davidson *et al* (1978) and may be attributed to such variables as agronomic practices, climare, soil moisture, harvest dates and crop maturity. All genotypes exhibited greater variability in seed size in response to spray frequency as indicated by a decrease in the CDF slope parameter γ. The greater variability may have been caused by fruit set over a longer time on the more healthy plants, thus contributing more small and immature seed to the sample lot. Consider for example the leafspot-susceptible genotype, Florunner, as shown in Fig 1. The sprayed treatments contained larger percentages of seed that rode the 7·94 mm (20/64 in) and larger size screens. Overall, the CDF shows only the relative proportion of seed in the various size categories, and does not indicate whether differences in treatments were caused by the loss of large, mature pods before harvest, decreased photosynthate availability, shading effects or some combination of these factors.

REFERENCES

AOCS 1969 *Official and Tentative Methods of the American Oil Chemists' Society* (3rd edn), Vol 1. American Oil Chemists' Society, Chicago, IL.

Basha S M M, Cherry J P, Young C T 1976 Changes in free amino acids, carbohydrates and proteins of maturing seeds from various peanut (*Arachis hypogaea* L.) cultivars. *Cereal Chem* **53** 586–597.

Beuchat L R, Smith D H, Young C T 1974 Effect of foliar fungicides on aflatoxin, oil and protein content and maturing rate of peanut kernels. *J Sci Food Agric* **25** 477–482.

Davidson J I Jr, Blankenship P D, Chew V 1978 Probability distributions of peanut seed size. *Peanut Sci* **5** 91–96.

Dreyer J, Duncan W G, McCloud D E 1981 Fruit temperature, growth rates, and yield of peanuts. *Crop Sci* **21** 686–688.

Gorbet D W, Shokes F M, Jackson L F 1982 Control of peanut leafspot with a combination of resistance and fungicide treatment. *Peanut Sci* **9** 87–90.

Gorbet D W, Norden A J, Shokes F M, Knauft D A, Pixley K V, Watson G R 1986 Leafspot disease assessment in breeding programs. *Proc Amer Peanut Res Educ Soc* **18** 67.

Henick A S, Benca M F, Mitchell J H Jr 1954 Estimating carbonyl compounds in rancid fats and foods. *J Am Oil Chem Soc* **31** 88–91.

Henning R J, McGill J F 1974 When to dig peanuts. *Ga Coop Ext Ser Peanut Release* No 53–79.

Hill R A, Blankenship P D, Cole R J, Sanders T H 1983 Effects of soil moisture and temperature in preharvest invasion of peanuts by *Aspergillus flavus* group and subsequent aflatoxin development. *Appl Environ Microbiol* **45** 628–633.

Holaday C E, Pearson J L 1974 Effects of genotype and production area on the fatty acid composition, total oil and total proteins in peanuts. *J Food Sci* **39** 1206–1209.

Ofiara D D, Allison J R 1984 Profile and pesticide use characteristics of Georgia peanut growers. *Univ of Ga College of Agric Report 448*.

Oupadissakoon C, Young C T, Mozingo R W 1980 Evaluation of free amino acid and free sugar contents in five lines of Virginia-type peanuts at four locations. *Peanut Sci* **7** 55–60.

Pattee H E, Johns E B, Singleton J A, Sanders T H 1974 Composition changes of peanut fruit parts during maturation. *Peanut Sci* **1** 57–62.

Porter D M 1970 Effectiveness of benomyl in controlling *Cercospora* leafspot of peanuts. *Plant Disease Reptr* **54** 955–958.

Sanders T H 1979 Fatty acid composition of lipid classes in oils from peanuts differing in variety and maturity. *J Amer Oil Chem Soc* **57** 12–15.

Sanders T H, Blankenship P D 1984 Effect of soil temperature on yield factors of Florunner peanuts (Abstr.). *Proc Amer Peanut Res Educ Soc* **16** 29.

Sanders T H, Lansden J A, Greene R L, Drexler J S, Williams E J 1982 Oil characteristics of peanut fruit separated by a nondestructive maturity classification method. *Peanut Sci* **9** 20–23.

Sanders T H, Blankenship P D, Cole R J, Hill R A 1985 Temperature relationships of peanut leaf canopy, stem, and fruit in soil of varying temperature and moisture. *Peanut Sci* **12** 86–89.

SAS Institute Inc 1985 *SAS User's Guide: Statistics, Version 5 Edition*. SAS Institute, Inc. Cary, NC.

Shokes F M, Gorbet D W, Jackson L F 1983 Control of early and late leafspot on two peanut cultivars. *Peanut Sci* **10** 17–21.

Williams E J, Ware G O, Lai J Y, Drexler J S 1988 Effect of pod maturity and plant age on pod and seed size distributions of Florunner peanuts. *Peanut Sci* **14** 79–83.

Worthington R E, Smith D H 1973 Effects of several foliar fungicides on the fatty acid composition and stability of peanut oil. *J Agric Food Chem* **21** 619–621.

Worthington R E, Smith D H 1974 Modification of peanut oil fatty acid composition by foliar applications of 2′,2′-dimethylsaccinohydrazide (Kylar). *J Agric Food Chem* **22** 507–508.

Young C T, Cecil S R, Smith D H 1972 Effect of leafspot control on the arginine maturity index of peanuts. *J Amer Peanut Res Educ Soc* **4** 52–57.